# Hydrological Outlook UK

Period: From March 2021

Issued on 09.03.2021 using data to the end of February 2021

**SUMMARY**

**The outlook for March is for normal to above normal river flows in south-east England, with flows within the normal range the most likely scenario in northern and western areas. Groundwater levels in March are likely to be normal to exceptionally high across the UK. The three-month outlook is very similar to the one-month outlook for both river flows and groundwater levels.**

**Rainfall:**

Rainfall in February was above average across central and southern Scotland, northern England, south Wales and eastern Northern Ireland. Below average rainfall was generally limited to parts of south-east England and particularly the far north of Scotland.

The rainfall outlook for March (issued by the Met Office on 22.02.2021) is that the chance of below-average precipitation is higher than normal. For March-April-May as a whole, below-average precipitation is slightly more likely than above-average precipitation. The probability that UK-average precipitation for March-April-May will fall into the driest of five categories is around 25% and the probability that it will fall into the wettest of five categories is around 15% (the 1981-2010 probability for each of these categories is 20%).

**River flows:**

February river flows were above normal or higher across the majority of England and Wales, notably or exceptionally so in south Wales and eastern England, and establishing new monthly flow maxima in some catchments draining into the North Sea.*

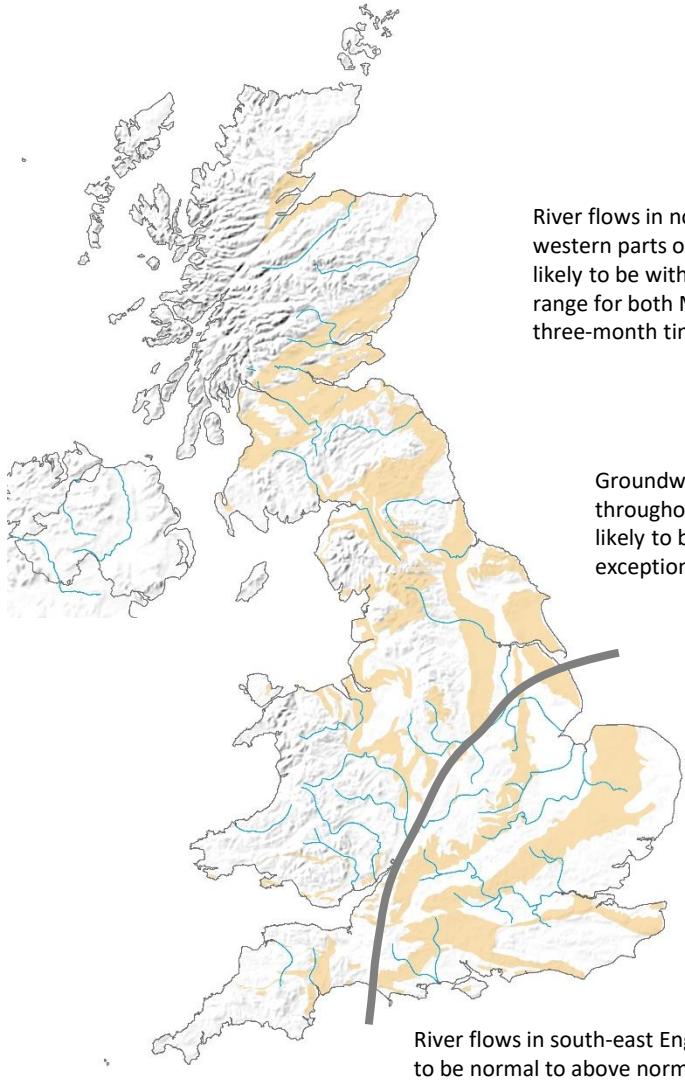
River flows in March are likely to be normal to above normal in south-east England, with above normal flows particularly likely in less responsive, often groundwater-influenced catchments. Further north and west, flows within the normal range are most likely. Over the three-month timeframe, the outlook is almost identical to that for March, once again with above normal flows more likely in slowly responding catchments of the south-east.

**Groundwater:**

Groundwater levels in February were above normal or notably high throughout the Chalk of southern England, and exceptionally high in aquifers of central and eastern England, where some boreholes established new February maximum levels.*

In most boreholes across England and Wales, March groundwater levels are likely to continue to span all categories from the normal range to exceptionally high. There is a strong likelihood of exceptionally high levels in some boreholes (particularly those around the Scottish borders) even under the driest rainfall scenarios. The outlook for the three-month timeframe is similar to that for March, although perhaps with more of a tendency towards levels within the normal range.

* Note: Due to unforeseen circumstances no data are available for Scotland



River flows in northern and western parts of the UK are most likely to be within the normal range for both March and the three-month timeframe

Groundwater levels throughout the UK are likely to be normal to exceptionally high in March

River flows in south-east England are likely to be normal to above normal in March and over the three-month timeframe

Shaded areas show principal aquifers

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UK Centre for Ecology & Hydrology | British Geological Survey | Department for Infrastructure An Roinn Bonneagair www.infrastructure-ni.gov.uk | Environment Agency | Met Office | Cyfoeth Naturiol Cymru Natural Resources Wales | SEPA Scottish Environment Protection Agency

# Hydrological Outlook UK



## About the Hydrological Outlook:

This document presents an outlook for the UK water situation for the next 1 – 3 months and beyond, using observational datasets, meteorological forecasts and a suite of hydrological modelling tools. The outlook is produced in a collaboration between the UK Centre for Ecology and Hydrology (UKCEH), British Geological Survey (BGS), the Met Office, the Environment Agency (EA), Natural Resources Wales (NRW), the Scottish Environment Protection Agency (SEPA), and for Northern Ireland, the Department for Infrastructure – Rivers (DfIR).

## Data and Models:

The Hydrological Outlook depends on the active cooperation of many data suppliers. This cooperation is gratefully acknowledged. Historic river flow and groundwater data are sourced from the UK National River Flow Archive and the National Groundwater Level Archive. Contemporary data are provided by the EA, SEPA, NRW and DfIR. These data are used to initialise hydrological models, and to provide outlook information based on statistical analysis of historical analogues.

Climate forecasts are produced by the Met Office. Hydrological modelling is undertaken by UKCEH using the Grid-to-Grid, PDM and CLASSIC hydrological models and by the EA using CATCHMOD. Hydrogeological modelling uses the R-groundwater model run by BGS and CATCHMOD run by the EA. Supporting documentation is available from the Outlooks website:
http://www.hydoutuk.net/methods

## Presentation:

The language used in the summary presented overleaf generally places flows and groundwater levels into just three classes, i.e. below normal, normal, and above normal. However, the underpinning methods use as many as seven classes as defined in the graphic to the right, i.e. the summary uses a simpler classification than some of the methods. On those occasions when it is appropriate to provide greater discrimination at the extremes the terminology and definitions of the seven class scheme will be adopted.

| | Percentile range of historic values for relevant month |
|---|---|
| Exceptionally high flow | > 95 |
| Notably high flow | 87-95 |
| Above normal | 72-87 |
| Normal range | 28-72 |
| Below normal | 13-28 |
| Notably low flow | 5-13 |
| Exceptionally low flow | < 5 |

## Disclaimer and liability:

The Hydrological Outlook partnership aims to ensure that all Content provided is accurate and consistent with its current scientific understanding. However, the science which underlies hydrological and hydrogeological forecasts and climate projections is constantly evolving. Therefore any element of the Content which involves a forecast or a prediction should not be relied upon as though it were a statement of fact. To the fullest extent permitted by applicable law, the Hydrological Outlook Partnership excludes all warranties or representations (express or implied) in respect of the Content.

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From April 2018 the Hydrological Outlook is supported by the Natural Environment Research Council funded UK-SCAPE and Hydro-JULES Programmes.

## Copyright:



## Further information:

For more detailed information about the Hydrological Outlook, and the derivation of the maps, plots and interpretation provided in this outlook, please visit the Hydrological Outlook UK website.

The website features a host of other background information, including a wider range of sources of information which are used in the preparation of this Outlook.

## Contact:

Hydrological Outlooks UK, UK Centre for Ecology & Hydrology, Wallingford, Oxfordshire, OX10 8BB
t: 01491 692371 e: enquiries@hydoutuk.net

## Reference for the Hydrological Outlook:

Hydrological Outlook UK, 2021, March, UK Centre for Ecology and Hydrology, Oxfordshire UK, Online,
http://www.hydoutuk.net/latest-outlook/

## Other Sources of Information:

The Hydrological Outlook should be used alongside other sources of up-to-date information on the current water resources status and flood risk.

Environment Agency Water Situation Reports: provides summary of water resources status on a monthly and weekly basis for England:
https://www.gov.uk/government/collections/water-situation-reports-for-england

Flood warnings are continually updated, and should be consulted for an up-to-date and localised assessment of flood risk:
Environment Agency: https://flood-warning-information.service.gov.uk/map
Scottish Environment Protection Agency: http://www.sepa.org.uk/flooding.aspx

Hydrological Summary for the UK: provides summary of current water resources status for the UK:
https://nrfa.ceh.ac.uk/monthly-hydrological-summary-uk

UK Met Office forecasts for the UK:
www.metoffice.gov.uk/public/weather/forecast/#?tab=regionalForecast

UK Water Resources Portal: monitor the UK hydrological situation in near real-time including rainfall, river flow, groundwater and soil moisture from COSMOS-UK:
https://eip.ceh.ac.uk/hydrology/water-resources/

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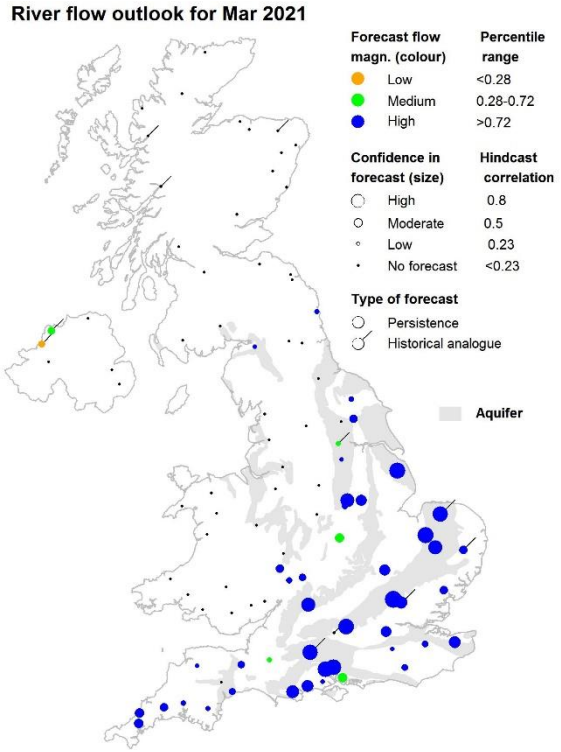
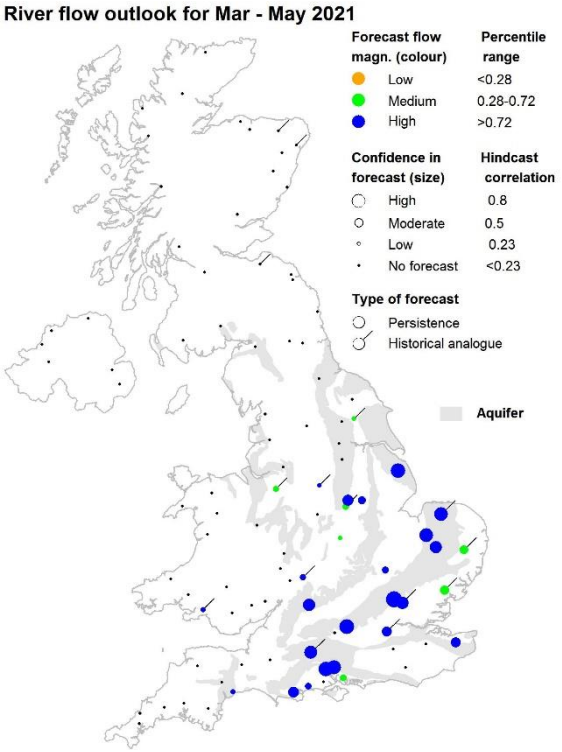
SUMMARY

The outlooks for March and for March-May are for normal to above normal flows in south, central and eastern England, with hardly any forecasts available for the rest of the UK.




1-month flow outlook




3-month flow outlook

Outlooks from hydrological analogues are based on a comparison of river flow during recent months with flows during the same months in previous years at a set of approximately 90 sites from across the UK. These sites are depicted on the two maps. Years with observed flows that most closely resemble current conditions are identified as the best analogues and the outlook is based on extrapolating from current conditions based on these analogues.

It is, however, often the case that a simpler forecast based on the persistence of river flow provides a better forecast than provided by analogy. This is particularly true for slowly responding catchments associated with aquifer outcrops.

Both methods are considered at each site and the forecast from the method with the higher confidence is presented. A simple classification of flows is used (high, medium and low) as indicated by the colours of the dots, with the confidence of the forecast being represented by the size of the dot. A tag on the dot indicates which method has been used in each instance.

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UK Centre for Ecology & Hydrology

# Outlook based on hydrological persistence and analogy

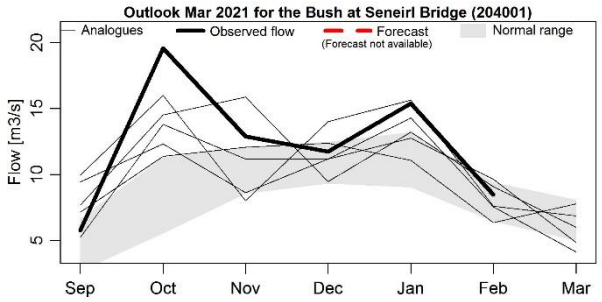
Site-based: 1 month outlook

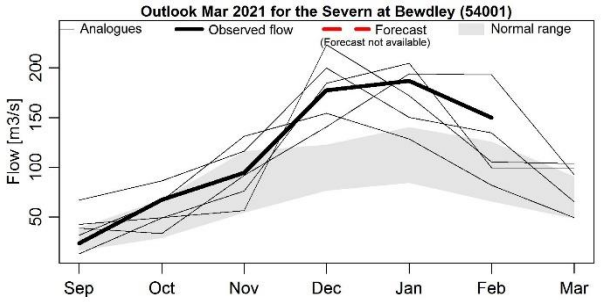
Period: March 2021

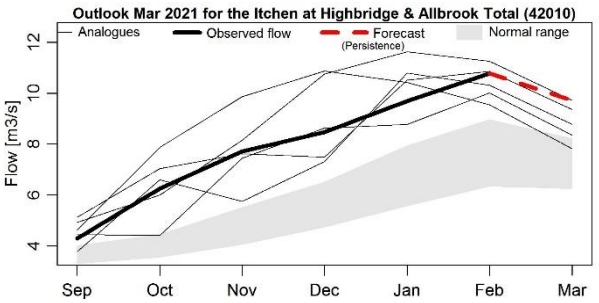
Issued on 05.03.2021 using data to the end of February 2021

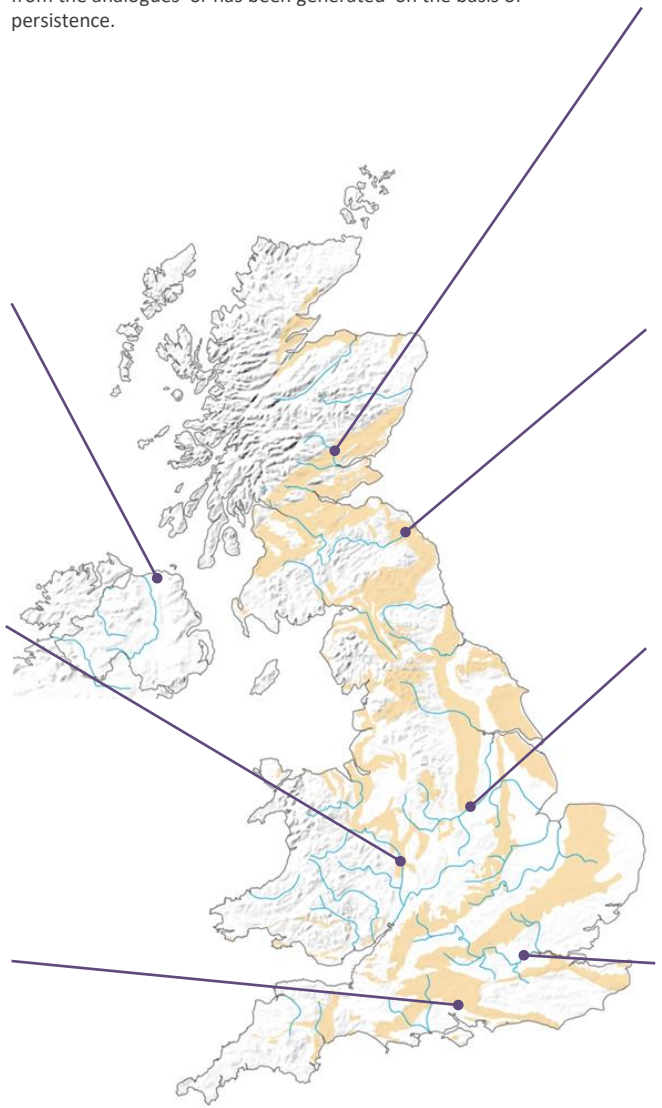
These figures provide insight into the hydrological analogue methodology for a set of sites from across the UK.

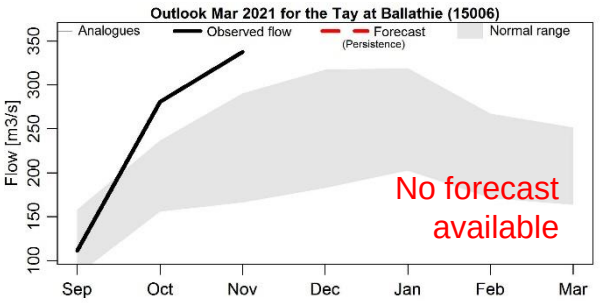
In each of the time series graphs the bold black line represents the observed flow during the past six months. The grey band indicates the normal flow range (the normal band includes 44% of observed flows in each month). The selected analogues are shown as thin lines and the trajectories that flows took in the following month are also shown. The forecast is shown as the dashed red line, and in each plot it states whether this has come from the analogues or has been generated on the basis of persistence.

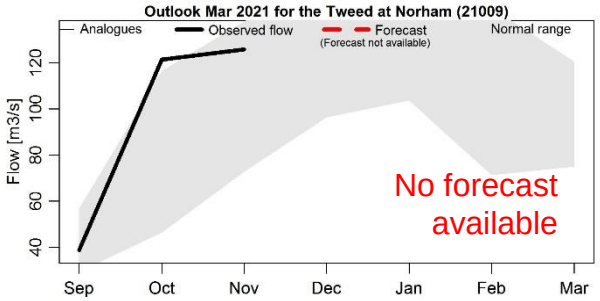


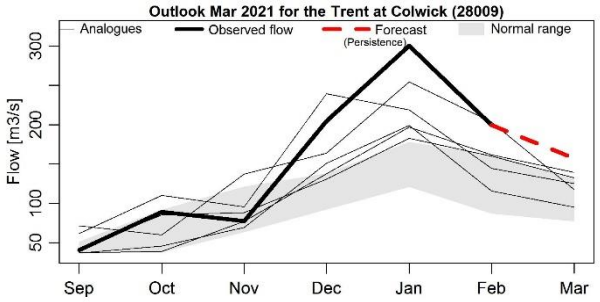



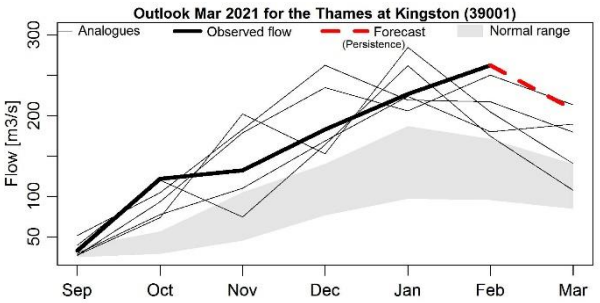



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RIVER FLOW ANALOGY

March 2021

UK Centre for Ecology & Hydrology

# Outlook based on hydrological persistence and analogy

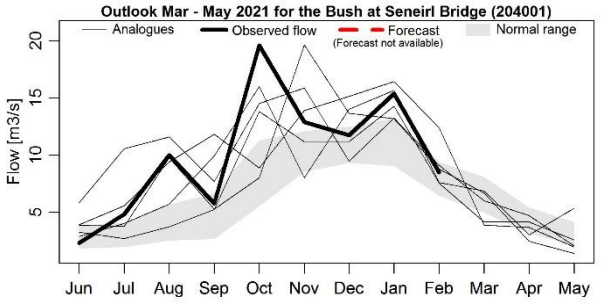
## Site-based: 3 month outlook

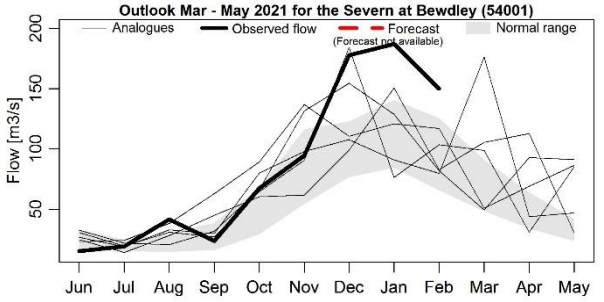
Period: March – May 2021

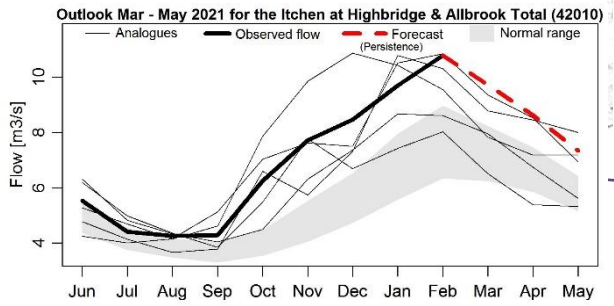
Issued on 05.03.2021 using data to the end of February 2021

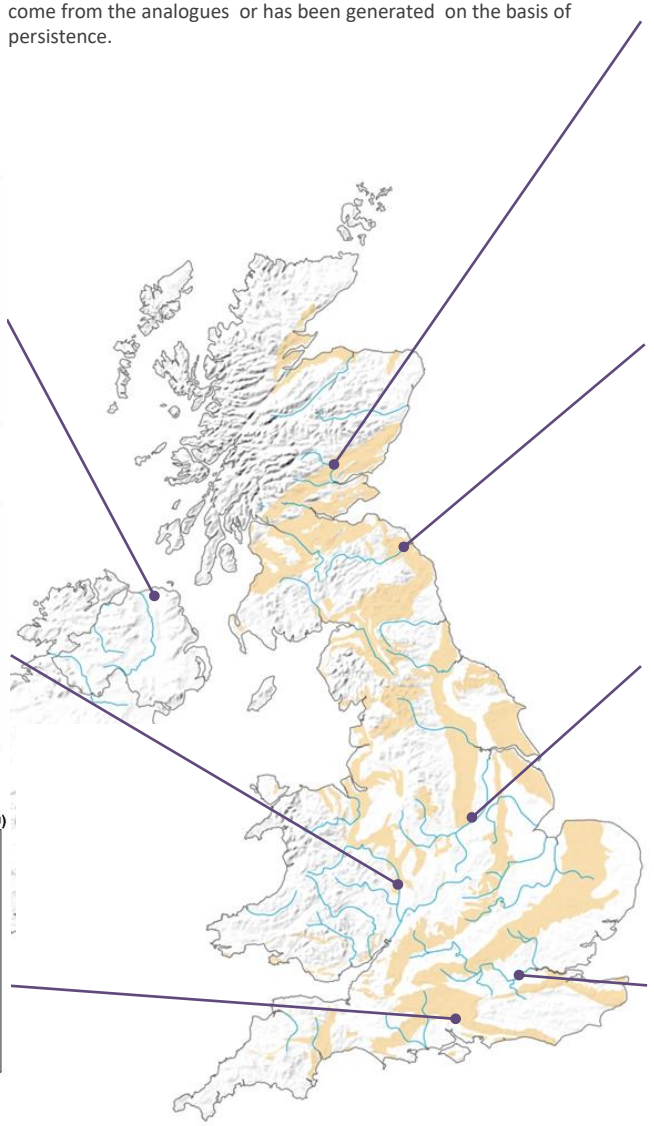
These figures provide insight into the hydrological analogue methodology for a set of sites from across the UK.

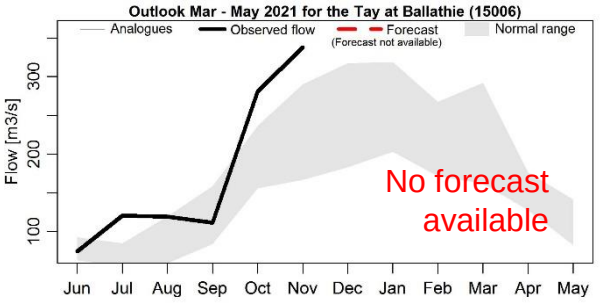
In each of the time series graphs the bold black line represents the observed flow during the past nine months. The grey band indicates the normal flow range (the normal band includes 44% of observed flows in each month). The selected analogues are shown as thin lines and the trajectories that flows took in the following three months are also shown. The forecast is shown as the dashed red line, and in each plot it states whether this has come from the analogues or has been generated on the basis of persistence.

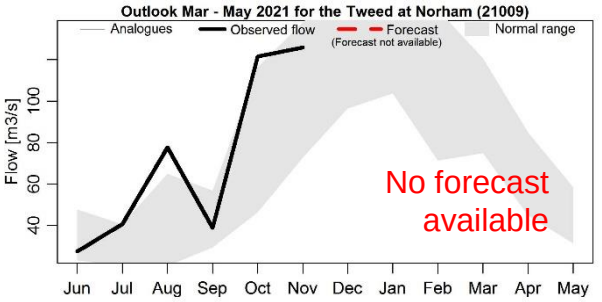


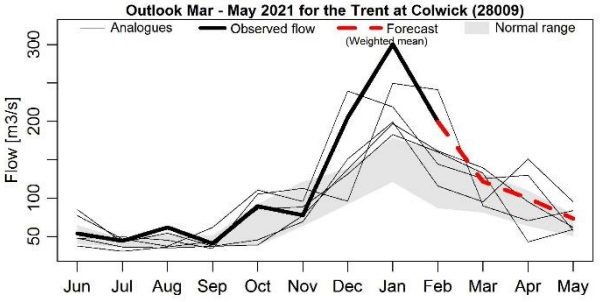



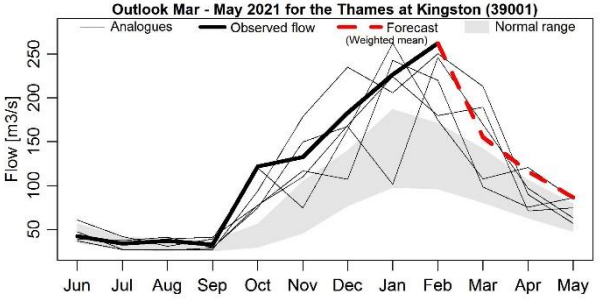



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RIVER FLOW ANALOGY

March 2021

UK Centre for Ecology & Hydrology

British Geological Survey

Environment Agency

# Outlook based on modelled flow from historical climate

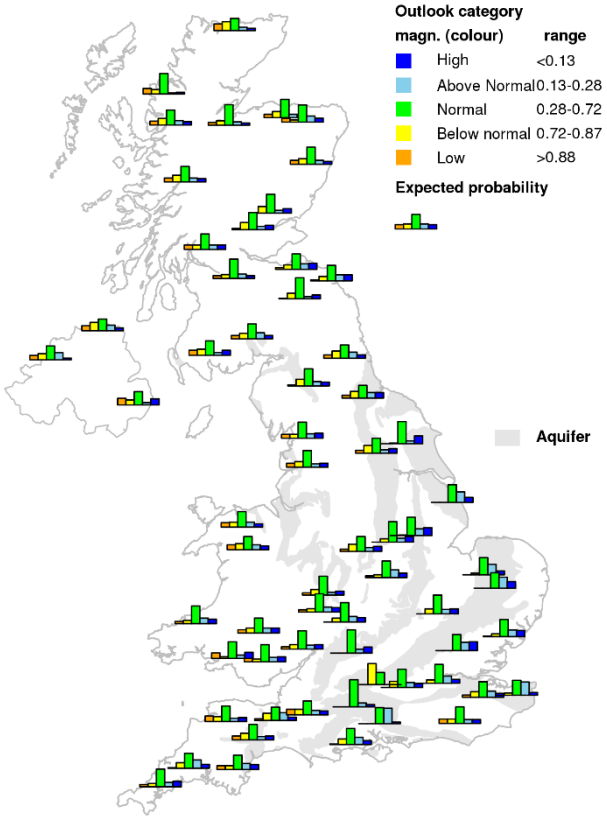
Overview

Period: March 2021 – August 2021

Issued on 03.03.2021 using data to the end of February 2021

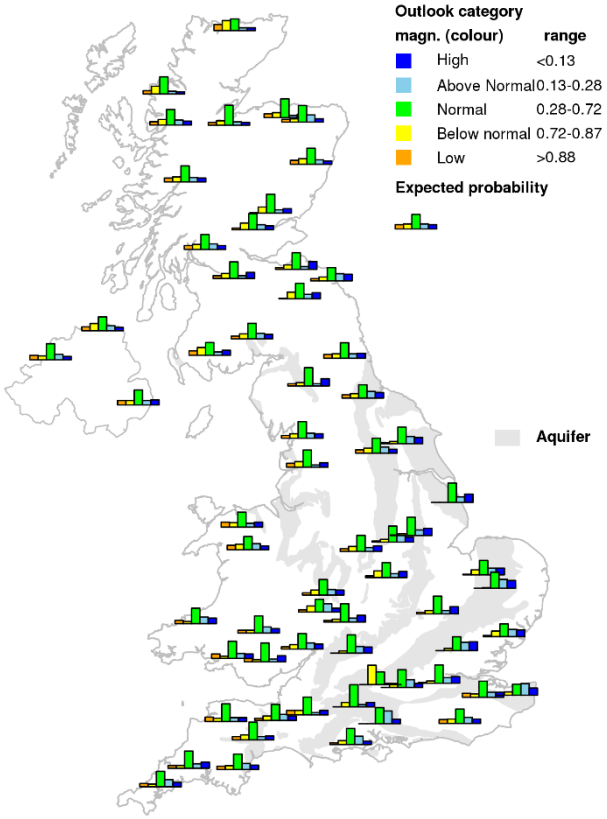
River flows are likely to be in the normal range across the UK in the 1 month outlook, with the exception of some chalk catchments in the south and east of England where normal to above normal flows are expected. This pattern is likely to persist into the 3 month outlook.

## 1-month river flow outlook starting Mar 2021



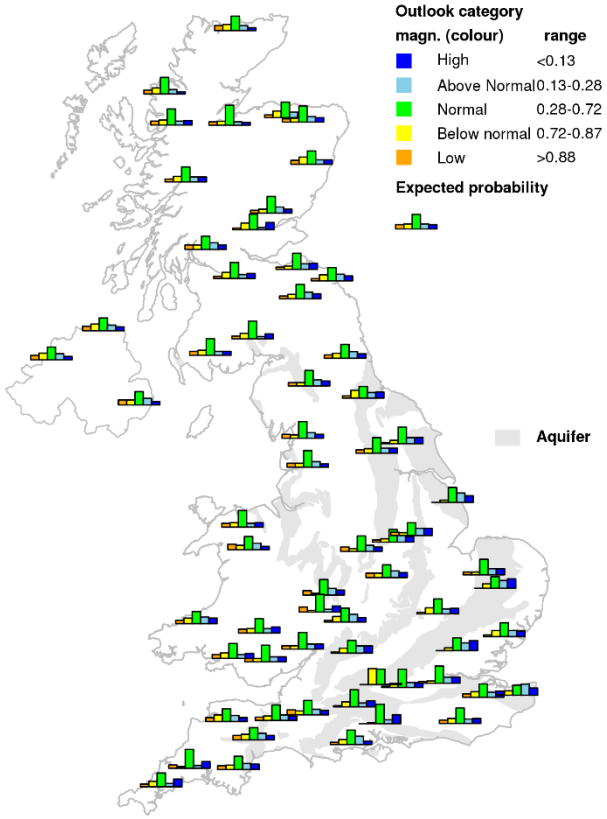

This outlook is based on monthly ensembles of historical sequences of observed climate (rainfall and potential evapotranspiration) that form input to a hydrological model. The outputs are probabilistic simulations of the average river flow over the forecast period (1 to 12 months ahead), at each location. The simulations are generated by the GR4J conceptual rainfall-runoff model from IRSTEA (France) calibrated on observed or naturalised flows.

## 3-month river flow outlook starting Mar 2021




The bar plot maps show the outlook distribution for 1, 3 and 6-month period for 64 catchments across England and Wales. Each bar plot represents the probabilistic distribution of the simulated river flow compared to the historical river flow, for the same n-month period. The probabilities fall within five categories, classified as: low, below normal, normal, above normal and high.

## 6-month river flow outlook starting Mar 2021




This outlook is based entirely on historical sequences and therefore does not contain any knowledge of the state of the atmosphere and ocean. It is hence possible that some of the historical sequences used might be inconsistent with current large-scale atmospheric conditions and would therefore be unlikely to occur in the next few months.

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UK Centre for Ecology & Hydrology

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# Outlook based on modelled flow from historical climate

Overview






This outlook is based on monthly ensembles of historical sequences of observed climate (rainfall and potential evapotranspiration) that form input to a hydrological model. The outputs are probabilistic simulations of the average river flow over the forecast period (1 to 12 months ahead), at each location. The simulations are generated by the GR4J conceptual rainfall-runoff model from IRSTEA (France) calibrated on observed or naturalised flows.

The stack diagrams show the variation over time of the outlook distribution for a number of individual catchments. Each graph represents variation over time of the number of simulated river flows, in each month ensemble, that fall within each of seven categories: exceptionally low, notably low, below normal, normal, above normal, notably high and exceptionally high. The categories represent cumulative flow conditions, e.g. For 3-month, the simulated total 3-month flow compared to the historical 3-month flow distribution. The monthly variations can be compared to the long-term average distribution of river flows (shown as columns on the right of each timeline graph).

This outlook is based entirely on historical sequences and therefore does not contain any knowledge of the state of the atmosphere and ocean. It is hence possible that some of the historical sequences used might be inconsistent with current large-scale atmospheric conditions and would therefore be unlikely to occur in the next few months.

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UK Centre for Ecology & Hydrology

# Current Daily Simulated Subsurface Water Storage Conditions

Based on subsurface water storage estimated for 28th February 2021

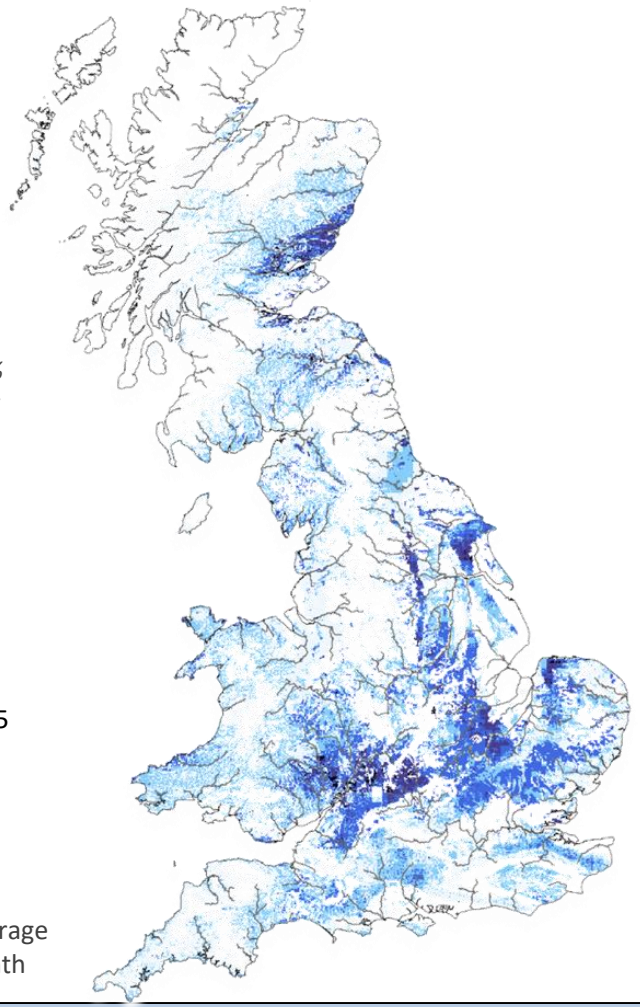
Issue date: 04.03.2021

These maps are based on Grid-to-Grid (G2G) hydrological model simulated subsurface water storage, expressed as an anomaly from the historical monthly mean. To highlight areas that are particularly wet or dry, the storage anomaly is presented here using a colour scale highlighting water storage relative to historical extremes. The maps below show relative wetness.

These maps do not provide a flood forecast and are not maps of soil moisture. Instead they indicate areas where subsurface water storage approaches or exceeds its historical maximum. Rainfall in the high 'relative wetness' areas could result in flooding.

**SUMMARY:** At the end of February, subsurface water levels across much of the country were mostly near average for this time of year with pockets of low to medium relative wetness, particularly in Central England and Eastern Scotland.

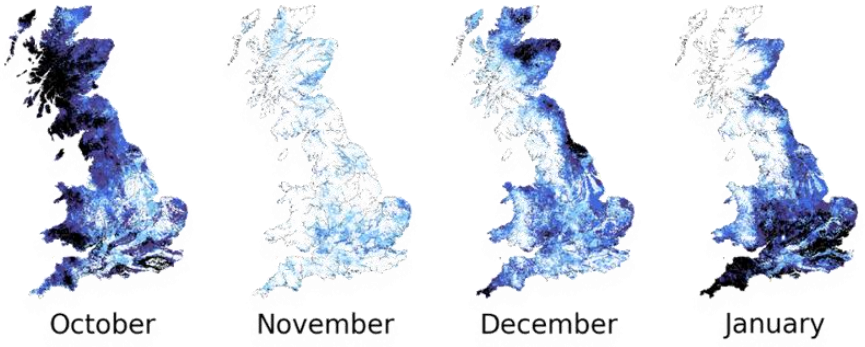
## Relative Wetness



*Water storage anomaly as a % of maximum storage anomaly (zero indicates average value)*

| | | |
|---|---|---|
| High (very wet) | | >100 |
| | | 75-100 |
| Medium | | 50-75 |
| | | 25-50 |
| Low | | 0.01-25 |
| (No wetness) | | <0 |
| Main rivers | | |

Labels refer to estimated storage on *final day* of named month






*Example month displaying extreme relative wetness

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OUTLOOK BASED ON CURRENT CONDITIONS

March 2021

UK Centre for Ecology & Hydrology

# Current Daily Simulated Subsurface Water Storage Conditions

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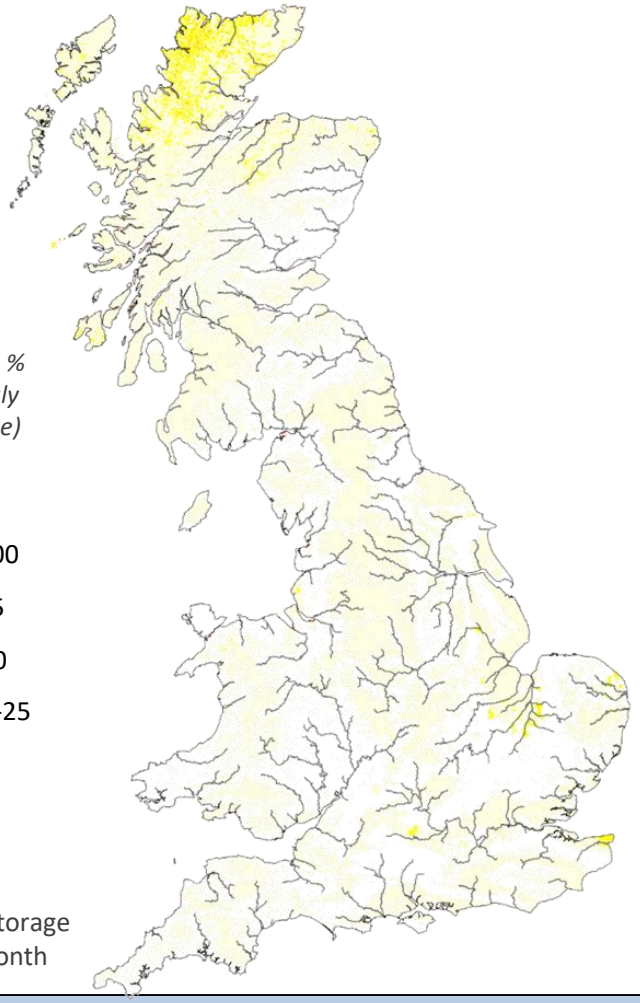
These maps do not provide a drought forecast and are not maps of soil moisture. Instead they indicate areas where subsurface water storage approaches or exceeds its historical minimum. A lack of rainfall in the high 'relative dryness' areas could lead to (or prolong) a drought.

**SUMMARY:** At the end of February, subsurface water levels across much of the country were mostly near average for this time of year, reflected in the no or low levels of relative dryness. Areas of exception include North West Scotland which have low to medium relative wetness.

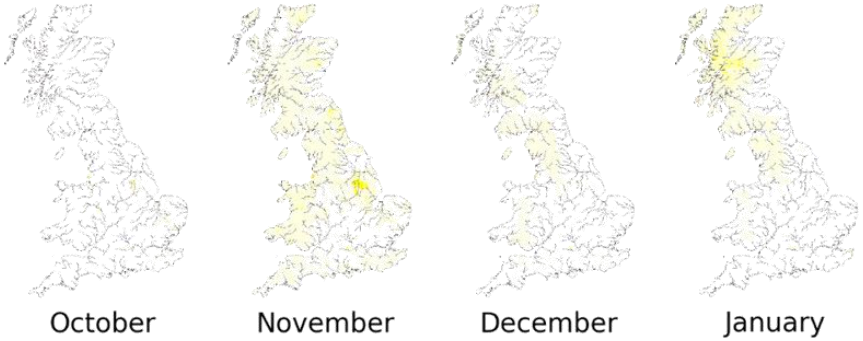
## Relative Dryness



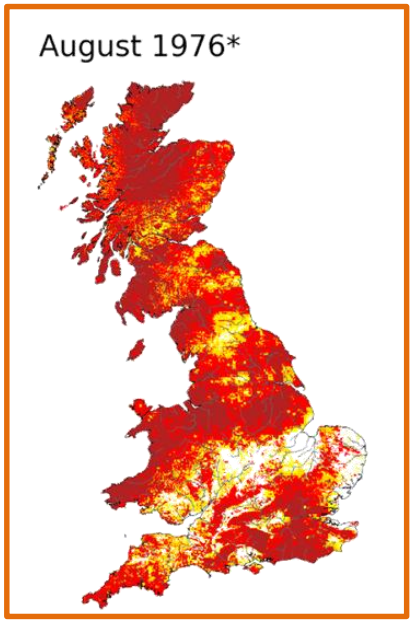
*Water storage anomaly as a % of minimum storage anomaly (zero indicates average value)*

| | | |
|---|---|---|
| High (very dry) | | >100 |
| | | 75-100 |
| Medium | | 50-75 |
| | | 25-50 |
| Low | | 0.01-25 |
| (No dryness) | | <0 |
| Main rivers | | |

Labels refer to estimated storage on *final day* of named month








*Example month displaying extreme relative dryness

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OUTLOOK BASED ON CURRENT CONDITIONS

March 2021

UK Centre for Ecology & Hydrology

# Current Daily Simulated Subsurface Water Storage Conditions



## Relative Dryness

- The relative dryness map highlights areas where current estimates of **subsurface water storage** (from the G2G hydrological model, calculated for the last day of last month) are particularly ***low***.
- The map indicates areas where the ground is dry compared to the monthly **average** storage (for the period 1981 to 2010), and shows this relative to the historical **minimum** storage level (for 1971 to 2010).
- Relative dryness calculation: $R_d\,(\%) = \frac{(S_{average} - S)}{(S_{average} - S_{min})} \times 100$

  $= \frac{\text{(average storage for this month - storage at end of last month)}}{\text{(average storage for this month - historical minimum storage)}} \times 100$
- A value of $\boldsymbol{R_d = 100}$ shows that a region is very dry, and indicates that the storage is as low as the minimum value ever estimated by the model for this month.
- A value of $\boldsymbol{R_d = 0}$ indicates that the storage in the region matches the monthly average value. *Negative relative dryness values will show up as part of the relative wetness map.*
- The map **does not provide a drought forecast**. A lack of rainfall in the high 'relative dryness' areas **could** lead to (or prolong) a drought.

## Relative Wetness

- The relative wetness map highlights areas where current estimates of **subsurface water storage** (from the G2G hydrological model, calculated for the last day of last month) are particularly ***high***.
- The map indicates areas where the ground is wet compared to the monthly **average** storage (for the period 1981 to 2010), and shows this relative to the historical **maximum** storage level (for 1971 to 2010).
- Relative wetness calculation: $R_w\,(\%) = \frac{(S - S_{average})}{(S_{max} - S_{average})} \times 100$

  $= \frac{\text{(storage at end of last month - average storage for this month)}}{\text{(historical maximum storage - average storage for this month)}} \times 100$
- A value of $\boldsymbol{R_w = 100}$ shows that a region is very wet, and indicates that the storage is as high as the maximum value ever estimated by the model for this month.
- A value of $\boldsymbol{R_w = 0}$ indicates that the storage in the region matches the monthly average value. *Negative relative wetness values will show up as part of the relative dryness map.*
- The map **does not provide a flood forecast**. Rainfall in the high 'relative wetness' areas **could** result in flooding.

UK Centre for Ecology & Hydrology

# Return Period of Rainfall Required to Overcome Dry Conditions

Period: March 2021 – August 2021

Issue date: 04.03.2021

These maps show the **return period** of the rainfall required to overcome dry conditions simulated using the Grid-to-Grid (G2G) hydrological model. The maps are coloured according to the return period of accumulated rainfall required to overcome the estimated current subsurface water storage deficit over the next few months.

These maps do not provide a drought forecast. Instead they indicate the return period of rainfall required to overcome the dry conditions for the following 6 months based on current conditions.

**SUMMARY:** During March to August, Britain will not require particularly unusual rainfall (<5 year return periods) to return to average conditions for the time of year.

Mar

Apr

May

Jun

Jul

Aug

| *Rainfall amount / Probability* | | *Return period (years)* |
|---|---|---|
| *Low (this rain is likely to occur)* | > 20% | < 5 |
| | < 20% | 5 - 10 |
| | < 10% | 10 - 25 |
| | < 4% | 25 - 50 |
| *High (less likely)* | < 2% | 50 - 100 |
| | < 1% | 100 - 200 |
| *Extreme (unlikely but still possible)* | < 0.5% | > 200 |

**SCOTLAND**

| | |
|---|---|
| HR | Highlands Region |
| NER | North East Region |
| TR | Tay Region |
| FR | Forth Region |
| CR | Clyde Region |
| TWR | Tweed Region |
| SR | Solway Region |

**ENGLAND**

| | |
|---|---|
| N | Northumbria |
| NW | North West |
| Y | Yorkshire |
| ST | Severn Trent |
| A | Anglian |
| T | Thames |
| S | Southern |
| W | Wessex |
| SW | South West |

**WALES**

| | |
|---|---|
| WEL | Welsh |


**NORTHERN IRELAND**
This method cannot currently be used in Northern Ireland

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OUTLOOK BASED ON CURRENT CONDITIONS

March 2021

# Return Period of Rainfall Required to Overcome the Dry Conditions



## Method

- These maps show the **return period** of the rainfall required to overcome dry conditions simulated using the Grid-to-Grid (G2G) hydrological model. The maps are coloured according to the return period of rainfall required to overcome the estimated current subsurface water storage deficit.

- For **dry areas** within a Hydrological Outlook region, i.e. where subsurface water storage anomaly < 0, we estimate ***regional average subsurface water storage deficit*** *(mm)* from the last day of the most recent G2G model run.

- For each region we also estimate the ***regional monthly average rainfall total*** *(mm)* (for the period 1971-2000).

- For each of the next 6 months, we estimate the rainfall total (including what is normally expected for each month) required to overcome the dry conditions.
  - To overcome the dry conditions by the end of month 1:
    rainfall required (mm) = regional monthly average rainfall for month 1 + regional average storage deficit
  - To overcome the dry conditions by the end of month 2 (more likely):
    rainfall required (mm) = regional monthly average rainfall for months 1 and 2 + regional average storage deficit
  - To overcome the dry conditions by the end of month *n* (likely):
    rainfall required (mm) = regional monthly average rainfall for months 1 to *n* + regional average storage deficit

- Using Tabony tables we estimate the return period of the ***rainfall required*** in each region and over the next 1 to 6 months to overcome the dry conditions.

- The return period results are displayed as regional maps with the colour scale based on the return period (years) of the rainfall required to replenish subsurface stores over the next 1, 2, .., 6 months ahead.

- Note: These maps do not provide a drought forecast. Instead they indicate the return period of rainfall required to overcome the dry conditions for the following 6 months based on current conditions.

UK Centre for Ecology & Hydrology

# Estimate of Additional Rainfall Required to Overcome Dry Conditions

## Based on subsurface water storage estimated for 28th February 2021

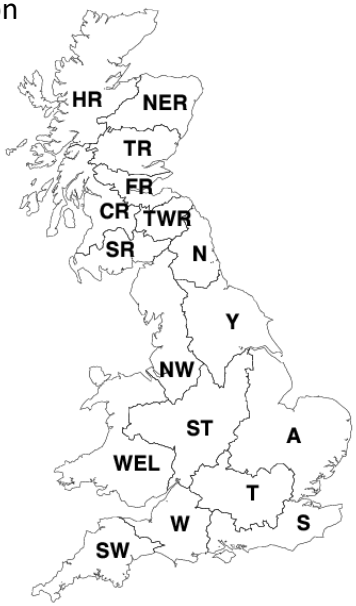
Issue date: 05.03.2021

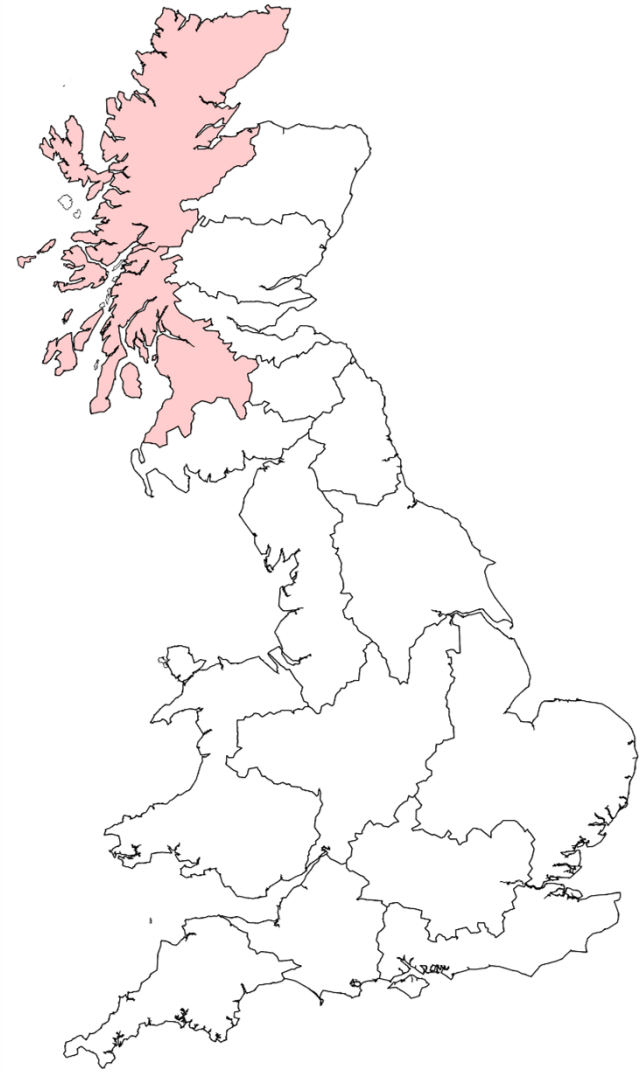
These maps show the Grid-to-Grid (G2G) hydrological model simulated subsurface water storage, expressed as an anomaly from the historical monthly mean (1981-2010), presented on a 1km grid and as regional means.
**Subsurface storage deficits**, i.e. where the subsurface water storage anomaly is less than zero, **are highlighted by the red/pink colours**.

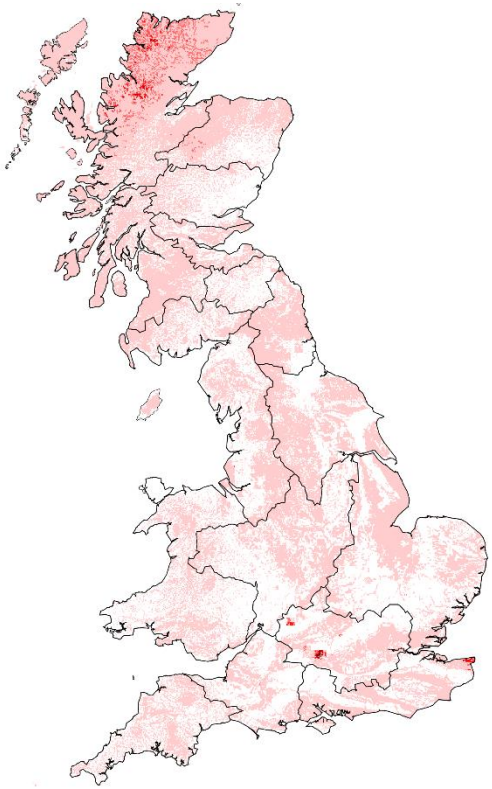
The **subsurface storage deficit (mm)** can be interpreted as an estimate of additional rainfall that would be required in future months to overcome dry conditions (i.e. rainfall in addition to what is expected on average). Regional mean values of additional rainfall required are provided in the table below.

*Regional estimate of additional rainfall required (mm)*

| | | |
|---|---|---|
| | **SCOTLAND** | |
| 11 | HR | Highlands Region |
| 0 | NER | North East Region |
| 0 | TR | Tay Region |
| 0 | FR | Forth Region |
| 2 | CR | Clyde Region |
| 0 | TWR | Tweed Region |
| 0 | SR | Solway Region |
| | **ENGLAND** | |
| 0 | N | Northumbria |
| 0 | NW | North West |
| 0 | Y | Yorkshire |
| 0 | ST | Severn Trent |
| 0 | A | Anglian |
| 0 | T | Thames |
| 0 | W | Wessex |
| 0 | S | Southern |
| 0 | SW | South West |
| | **WALES** | |
| 0 | WEL | Welsh |





*Water storage deficit (anomaly, mm)*

- >125
- 100-125
- 75-100
- 50-75
- 25-50
- 0.1-25
- ≤0

OUTLOOK BASED ON CURRENT CONDITIONS

March 2021

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UK Centre for Ecology & Hydrology

# Outlook Based on Modelled Flow from Rainfall Forecasts

Overview

Period: March 2021 – May 2021

Issued on 04.03.2021 using data to the end of February

**SUMMARY:** During March, river flows across the country are most likely to be in the *Normal range*.

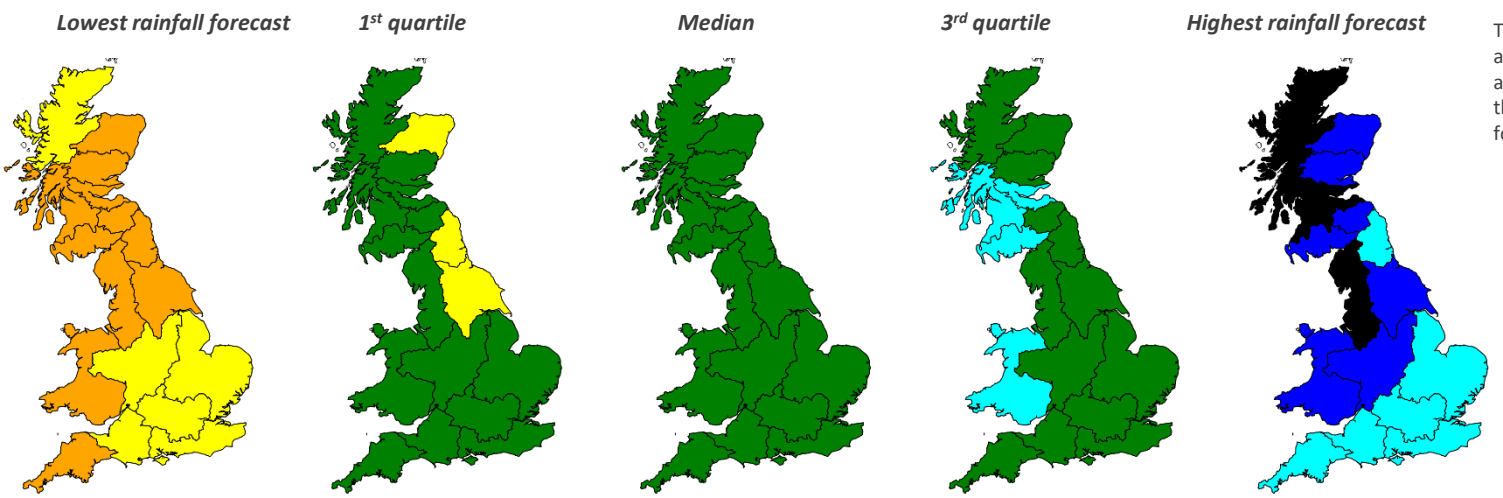
**Over the next 3 months** river flows across the country are most likely to be in the *Normal range,* with a tendency towards *Below normal* in most areas except South East England.

These forecasts are produced by using five members of the Met Office rainfall forecast ensemble as input to a water balance hydrological model to provide the five estimates of river flows shown on the left for one month and three months ahead.

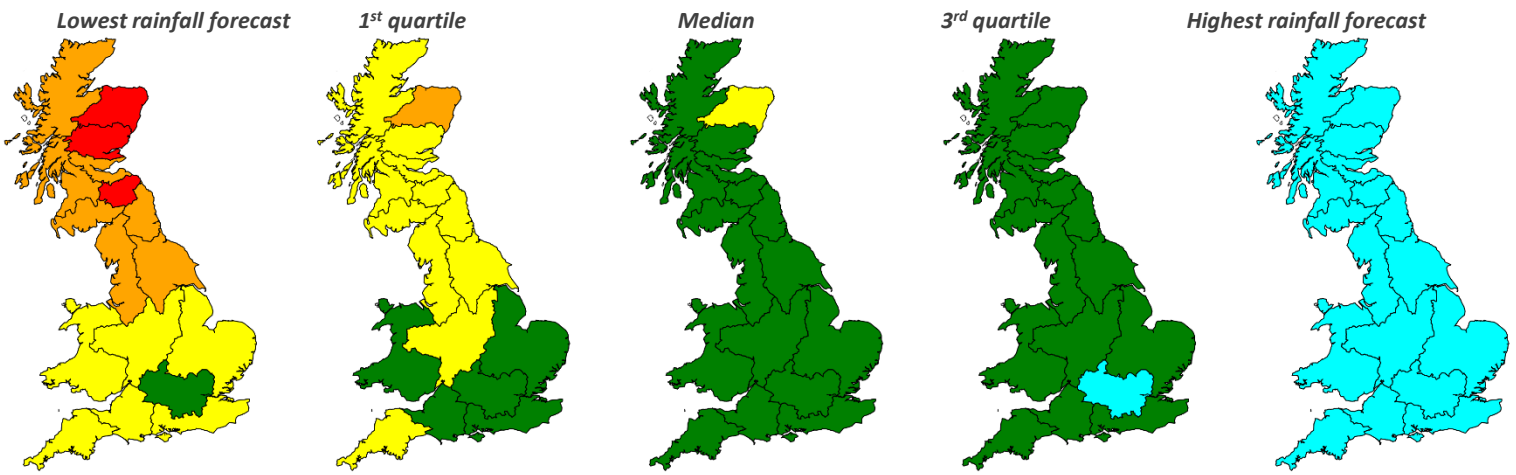
Regional forecast monthly-mean river flows are derived from the average of 1km river flow estimates within each region and ranked in terms of 54 years of historical flow estimates (1963 – 2016).

The five maps illustrate the wide range of possible flows and while there is a 50% chance of flows between the 1st and 3rd quartiles, actual flows may be more extreme than the flows derived using the highest or lowest rainfall forecasts.

## 1-month flow outlook




## 3-month flow outlook




**Key**

| | Percentile range of historic values for relevant month |
|---|---|
| Exceptionally high flow | > 95 |
| Notably high flow | 87-95 |
| Above normal | 72-87 |
| Normal range | 28-72 |
| Below normal | 13-28 |
| Notably low flow | 5-13 |
| Exceptionally low flow | < 5 |

**SCOTLAND**

| | |
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**ENGLAND**

| | |
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**WALES**

| | |
|---|---|
| WEL | Welsh |


**NORTHERN IRELAND**

This method cannot currently be used in Northern Ireland

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RIVER FLOW FROM RAINFALL FORECASTS

March 2021

UK Centre for Ecology & Hydrology

# Outlook Based on Modelled Flow from Rainfall Forecasts 1- and 3-month variability

Period: March 2021 – May 2021

Issue date: 04.03.2021

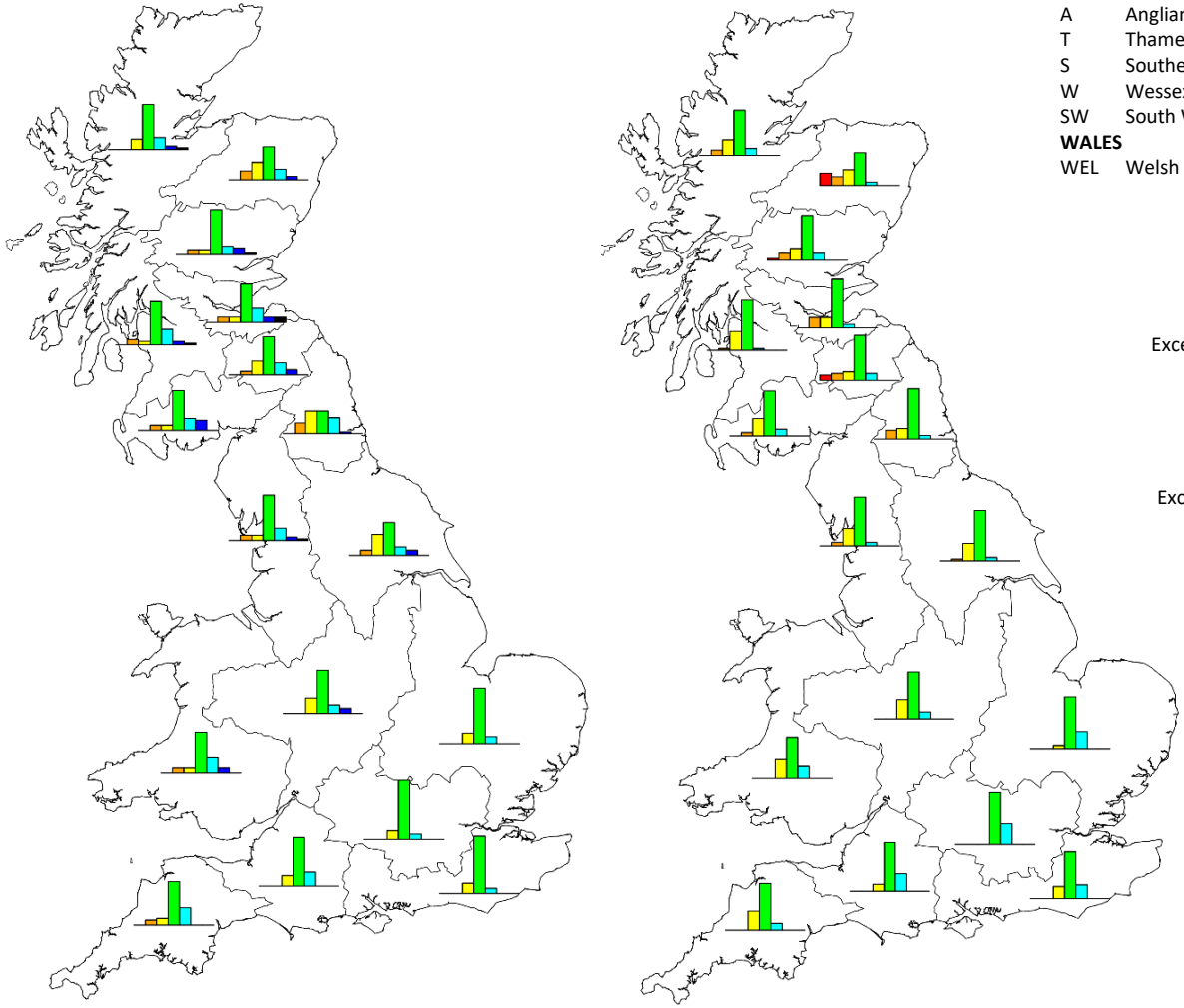
The regional maps illustrating the regional river flows for five members of the Met Office ensemble of rainfall forecasts give some indication of the range of possible river flows in the coming months. As noted previously, the actual flows could be more extreme than the flows generated by either the lowest or highest members of the rainfall ensemble.

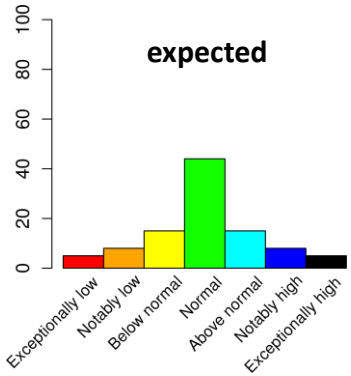
The bar charts (below) give further insight into the range of river flow forecasts by considering all members of the forecast rainfall ensemble. The regional bar charts show the percentage of ensemble forecasts falling in each of the flow categories as generated by the monthly-resolution water-balance model. As before results are averaged by region then ranked in terms of 54 years of historical regional flow estimates (1963 – 2016).


**SUMMARY:** During March, river flows across the country are most likely to be in the *Normal range*.

**Over the next 3 months** river flows across the country are most likely to be in the *Normal range,* with a tendency towards *Below normal* in most areas except South East England.


*1-month* *3-month*






**SCOTLAND**

| | |
|---|---|
| HR | Highlands Region |
| NER | North East Region |
| TR | Tay Region |
| FR | Forth Region |
| CR | Clyde Region |
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**ENGLAND**

| | |
|---|---|
| N | Northumbria |
| NW | North West |
| Y | Yorkshire |
| ST | Severn Trent |
| A | Anglian |
| T | Thames |
| S | Southern |
| W | Wessex |
| SW | South West |

**WALES**

| | |
|---|---|
| WEL | Welsh |


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Percentile range of historic values for relevant month

| | |
|---|---|
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| Normal range | 28-72 |
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Period: March 2021 – May 2021

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The maps illustrating the regional river flows for five members of the Met Office ensemble of rainfall forecasts give some indication of the range of possible river flows in the coming months. As noted previously, the actual flows could be more extreme than the flows generated by either the lowest or highest members of the rainfall ensemble.

The tables below give further insight into the range of river flow forecasts by considering all members of the forecast rainfall ensemble. The numbers in the tables are the percentage of ensemble forecasts falling in each of the flow categories as generated by the monthly-resolution water-balance model. As before results are averaged by region then ranked in terms of 54 years of historical regional flow estimates (1963 – 2016).

**SUMMARY:** During March, river flows across the country are most likely to be in the *Normal range*.

**Over the next 3 months** river flows across the country are most likely to be in the *Normal range,* with a tendency towards *Below normal* in most areas except South East England.

**SCOTLAND**
HR Highlands Region
NER North East Region
TR Tay Region
FR Forth Region
CR Clyde Region
TWR Tweed Region
SR Solway Region
**ENGLAND**
N Northumbria
NW North West
Y Yorkshire
ST Severn Trent
A Anglian
T Thames
S Southern
W Wessex
SW South West
**WALES**
WEL Welsh


**NORTHERN IRELAND**
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| 1-month ahead | A | NW | N | ST | SW | S | T | Welsh | W | Y | CR | FR | HR | NER | SR | TR | TWR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Exceptionally high flow | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 7 | 2 | 0 | 0 | 2 | 0 |
| Notably high flow | 0 | 5 | 2 | 7 | 0 | 0 | 0 | 7 | 0 | 7 | 5 | 7 | 5 | 5 | 14 | 10 | 7 |
| Above normal | 10 | 17 | 21 | 12 | 24 | 7 | 7 | 21 | 19 | 12 | 21 | 19 | 17 | 14 | 17 | 12 | 17 |
| Normal range | 76 | 62 | 31 | 60 | 60 | 79 | 81 | 57 | 67 | 45 | 60 | 52 | 62 | 45 | 55 | 62 | 52 |
| Below normal | 14 | 7 | 31 | 21 | 10 | 14 | 12 | 7 | 14 | 29 | 5 | 7 | 14 | 24 | 7 | 7 | 19 |
| Notably low flow | 0 | 7 | 14 | 0 | 7 | 0 | 0 | 7 | 0 | 7 | 7 | 7 | 0 | 12 | 7 | 7 | 5 |
| Exceptionally low flow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| 3-months ahead | A | NW | N | ST | SW | S | T | Welsh | W | Y | CR | FR | HR | NER | SR | TR | TWR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Exceptionally high flow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Notably high flow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Above normal | 24 | 5 | 5 | 10 | 10 | 19 | 29 | 17 | 24 | 5 | 2 | 5 | 10 | 5 | 10 | 10 | 10 |
| Normal range | 71 | 67 | 69 | 64 | 64 | 64 | 71 | 57 | 67 | 69 | 69 | 67 | 62 | 45 | 62 | 62 | 62 |
| Below normal | 5 | 24 | 14 | 26 | 26 | 17 | 0 | 26 | 10 | 24 | 26 | 14 | 21 | 21 | 24 | 17 | 12 |
| Notably low flow | 0 | 5 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 14 | 7 | 12 | 5 | 10 | 10 |
| Exceptionally low flow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 0 | 2 | 7 |

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British Geological Survey

# Outlook based on modelled groundwater level & climate forecast

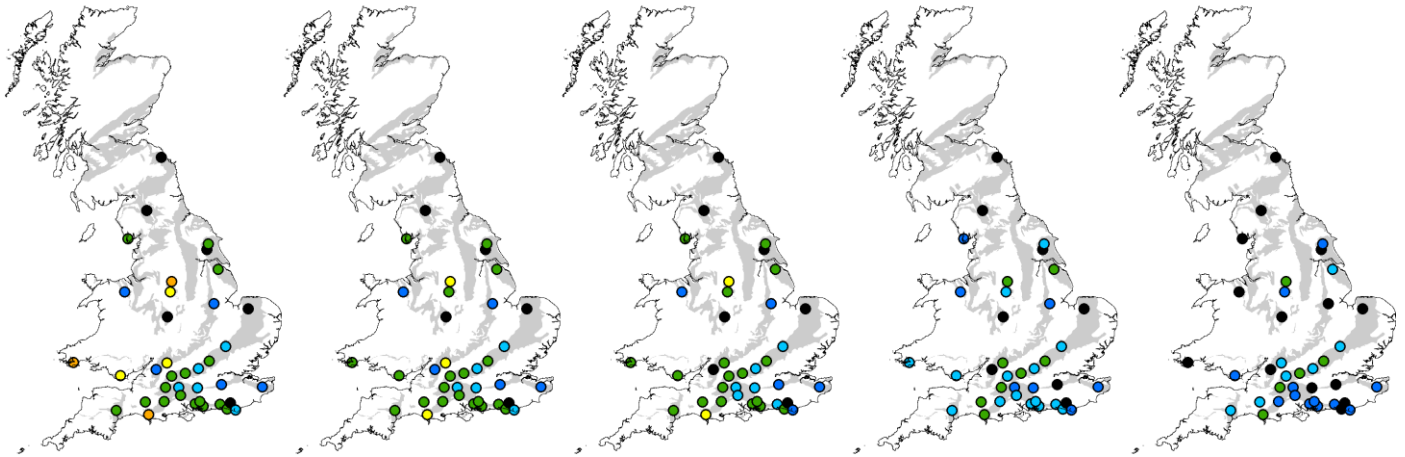
Overview

Period: March 2021 – May2021

Issued on 08. 03.2021 using data to the end of February

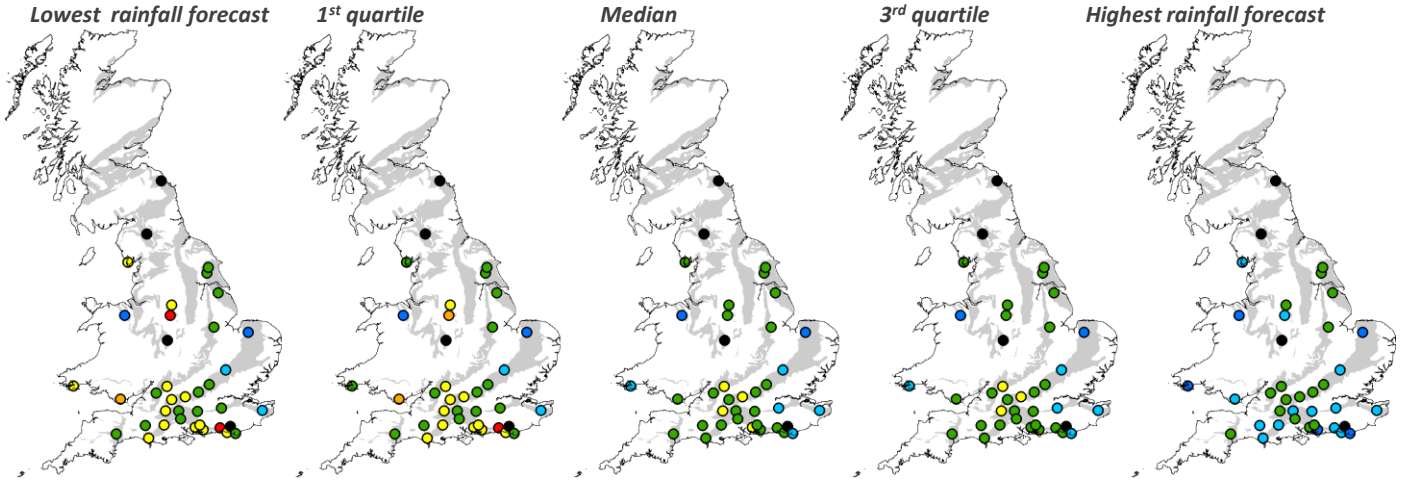
Generally, normal to above normal groundwater levels are predicted across England and Wales in the next month, with levels becoming more normal in the 3-month forecast. Groundwater levels in the Chalk aquifers may become notably or exceptionally high under high rainfall scenarios in the 1-month and 3-month forecasts. Elsewhere, exceptionally high levels are predicted under all rainfall scenarios at the Skirwith (Permo-Triassic sandstone) and Royalty Observatory (Fell Sandstone) sites in both the 1-month and 3-month forecasts. Note there are a reduced number of modelled sites. This is due to Covid-19 restrictions on access to sites in England and IT issues in Scotland.

*Lowest rainfall forecast* | *1st quartile* | *Median* | *3rd quartile* | *Highest rainfall forecast*



**1-month outlook**

*Lowest rainfall forecast* | *1st quartile* | *Median* | *3rd quartile* | *Highest rainfall forecast*

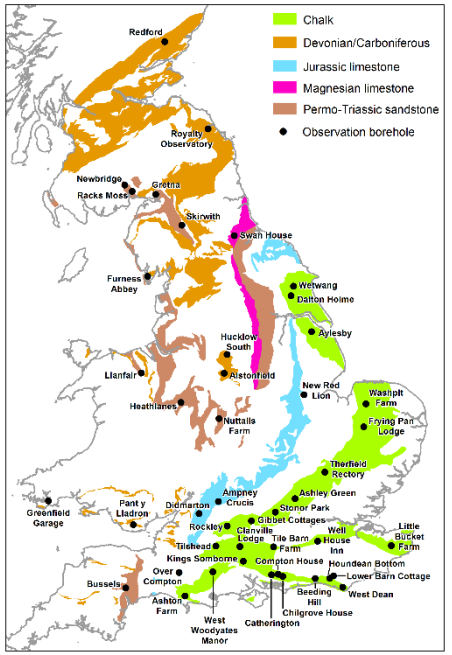


**3-month outlook**

These forecasts are produced by running five members of the Met Office ensemble climate forecast through groundwater models of observation borehole hydrographs at 42 sites across the country. The sites are distributed across the principal aquifers.

Based on the distribution of observed historical groundwater levels in a given month, seven categories have been derived for each site: very low, low, below normal, normal, above normal, high, and very high. The forecast groundwater level is assigned to one of these seven categories depending on where it falls within the distribution of the historically observed values.

| **Key** | Percentile range of historic observed values for relevant month |
|---|---|
| Exceptionally high levels | > 95 |
| Notably high levels | 87-95 |
| Above normal | 72-87 |
| Normal | 28-72 |
| Below normal | 13-28 |
| Notably low levels | 5-13 |
| Exceptionally low levels | < 5 |

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GROUNDWATER FROM CLIMATE FORECASTS

March 2021

UK Centre for Ecology & Hydrology

British Geological Survey

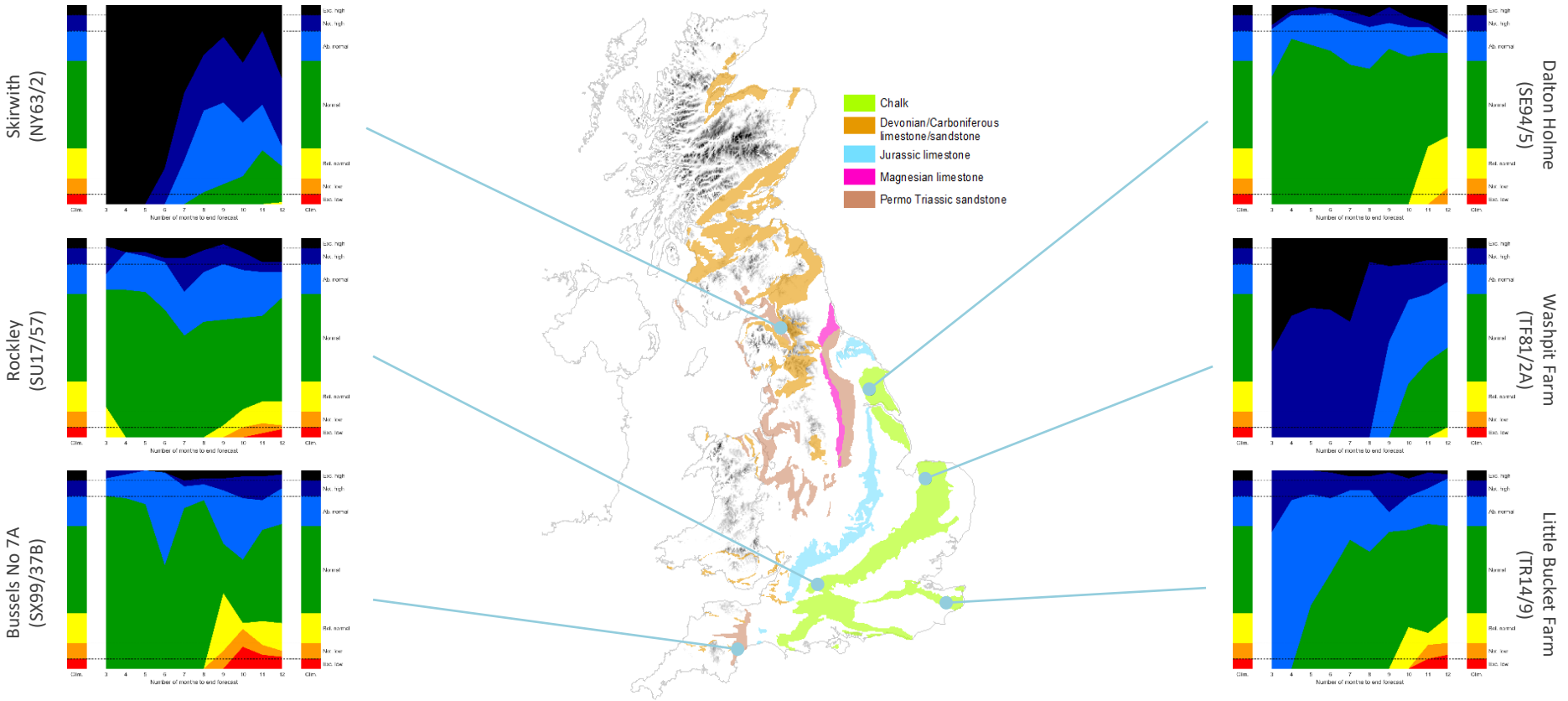
Environment Agency

# Outlook based on modelled groundwater from historical climate

Period: March 2021 – February 2021

Issued on 08.03.2021 using data to the end of February

Notably high to exceptionally high levels are predicted in the Permo-Triassic sandstone at Skirwith in North West England over the next 6 months. Throughout the Chalk aquifer normal to above normal levels are forecast for the next 12 months with the exception of Washpit Farm where levels are likely to be notably to exceptionally high in the next 6 months.




This outlook is based on monthly ensembles of historical sequences of observed climate (rainfall and potential evpotranspiration) that form input to hydrological models. The outputs are probabilistic simulations of the average groundwater level over the forecast horizon (3 to 12 months ahead), at each location.

The graphs show variation over time of the number of simulated groundwater levels in each monthly ensemble, that fall within each the seven categories: exceptionally low, notably low, below normal, normal, above normal, notably high and exceptionally high. The monthly variations can be compared to the long-term average distribution of levels, which are shown as columns on the left and right of each graph.

This outlook is based entirely on historical sequences and therefore does not contain any knowledge of the state of the atmosphere and ocean. It is hence possible that some of the historical sequences used might be inconsistent with current large-scale atmospheric conditions and would therefore be unlikely to occur in the next few months.

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